wE3.3 Vertical positioning Datums

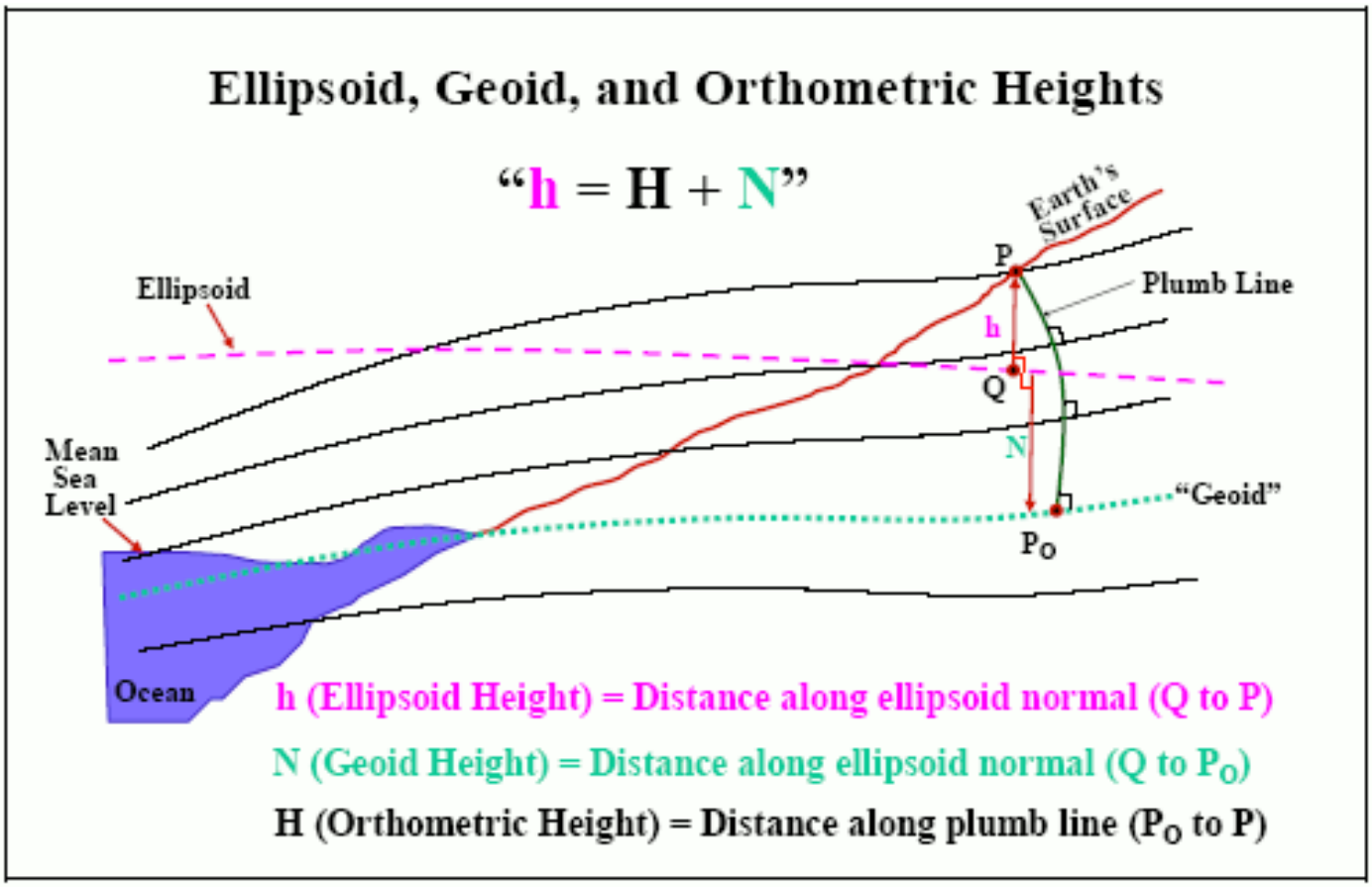

Figure 1 https://vdatum.noaa.gov/docs/datums.html

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Introduction:

During my third school year for the education course Ocean Technology at the maritime institute Willem Barentsz on the Dutch's island of Terschelling I had to an internship of 100 days with a hydrographical company in my case Geoxyz. For my internship, I had to do a certain amount of internship assignment such as three SOC assignment and below I will talk about one specific subject namely E3.3 Vertical height datum s and my internship experience with the subject

Summary

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Geoid

The mean surface of the earth is the Geoid. The earth would only be shaped like a geoid if the average sea surface would cover the entire earth and there are no other external factors such as tidal movement, wind or other. On a geoid, the gravity is everywhere perpendicular to the geoid. The Geoid is equipotential plane so this means that gravity produce everywhere the same amount of energy to keep a point to the geoid. Initially there only one geoid and that when every it is mean sea-level what would give the earth a radius of about 6370 Kilometre but because of the sheer weight of the earth and the rotation speed of the earth, the earth is pushed outworths near the equator and flattens on the poles which would make it more look like a flattened spheroid and not a prolate spheroid what would look more like a geoid. This has all been calculated in the last 50 years because of new technology's that could help with complex equation and the help of satellites.

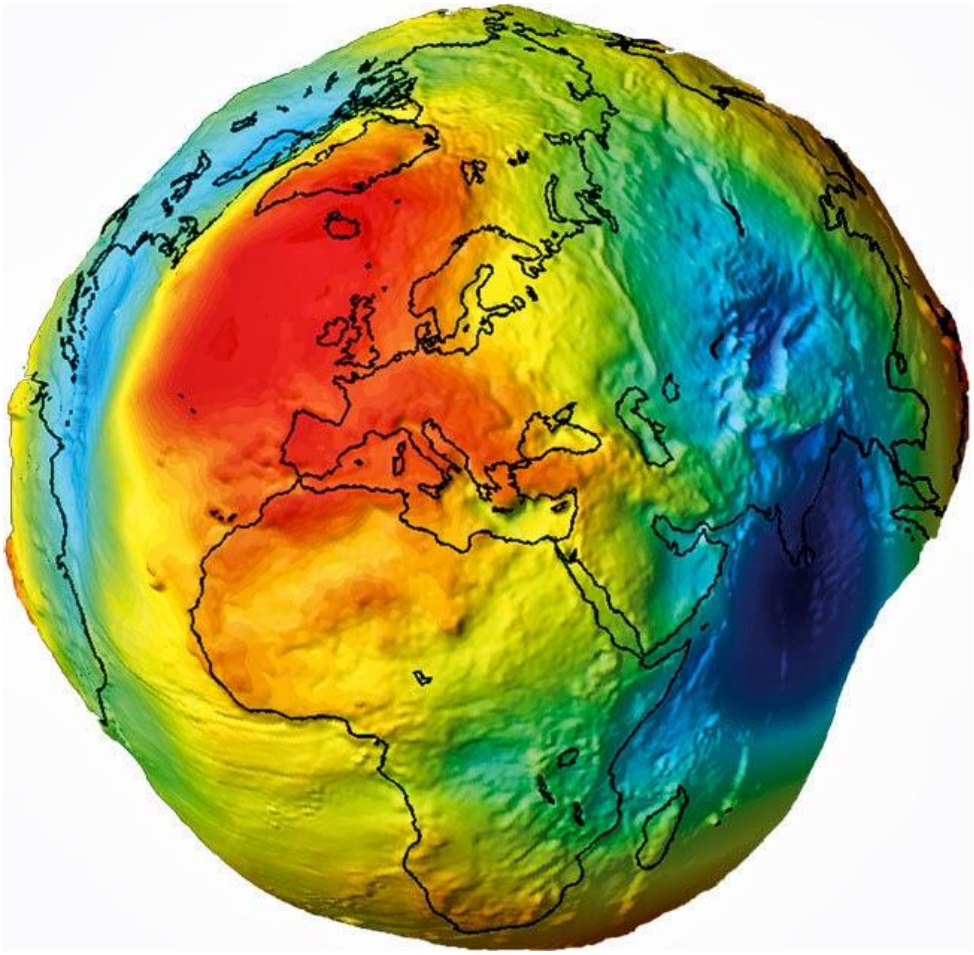

Figure 2 http://deepearthscience.blogspot.nl/2013/10/measuring-geoid-what-is-geoid.html

The reference Ellipsoid

The reference ellipsoid is the mathematically defined surface of the earth which it is close to the geoid (the truer figure of the earth) but is easier to calculate and is also preferred in usage of geodetiek systems. Many reference ellipsoids have been defined because each individual ellipsoid is closer to the true earth then another ellipsoid but only for a certain area of the earth.

The primary usage for reference ellipsoid serve as a basis for a coordinate system longitude latitude and height. For this to happens first the need to be a zero-meridian selected in earths case it is most of the time the prime meridian.

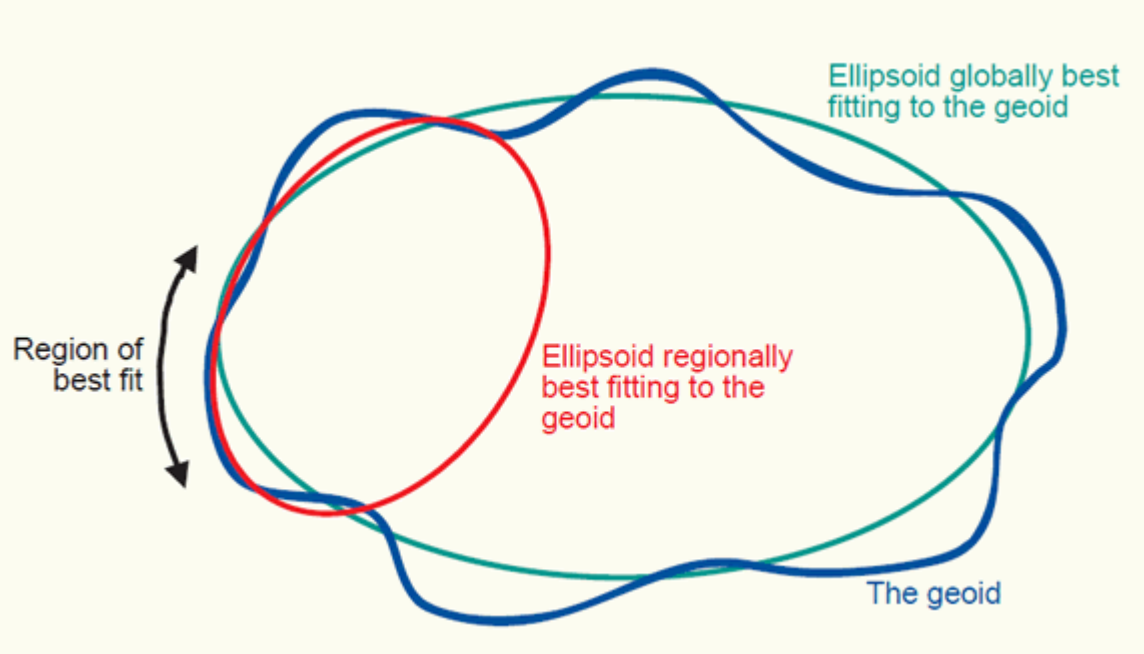

Figure 3https://kartoweb.itc.nl/geometrics/Reference%20surfaces/refsurf.html

Geographical Coordinates

Geographical coordinates are used to determine your position on earth and are still in common use because a chart normally has 360 degrees in longitude direction and 180 degrees in latitude direction.

The longitude is the rotation angle from the zero meridian and the measured point

The latitude measures how close to the equator or poles a point is on the meridian. It has an opening angle of 180 degrees but the angle for the equator is 0 so the scale of from -90 degrees to +90 degrees. The geodetiek latitude is the angle between the equatorial plane and the line that is normal to the reference ellipsoid. Depending on the flattening it may be slightly different from the geocentric latitude which is the angle between the equatorial plane and a line from the centre of the ellipsoid

The coordinates of a certain geodetiek point are normally stated as geodetic latitude and longitude and height

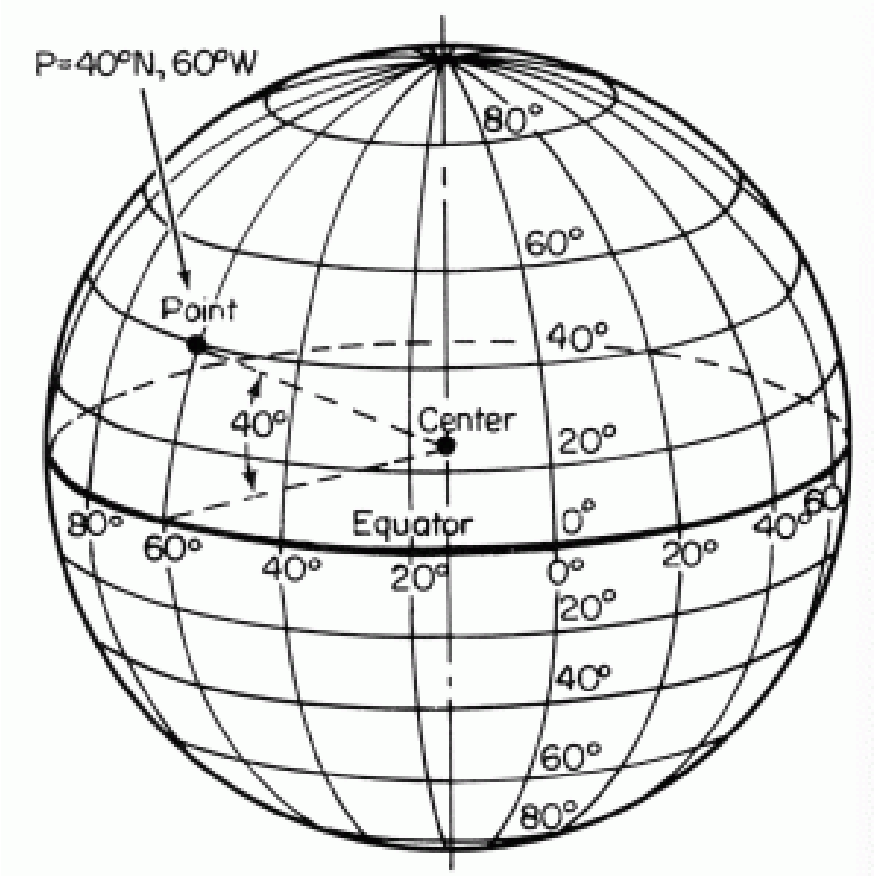

Figure 4 http://blog.karmona.com/index.php/2010/10/09/karmona-labs-on-geo-distance/

Geodetic Datum

A geodetic datum is the relationship between the earth and specified kind of geodetic coordinate system. Because of the shape of the earth is a geoid there cannot be a perfectly fitting reference datum made for the entire earth. Therefor several datums have been made to best fit a certain area namely a horizontal datum and a datum that best fits for height in a certain area that is called a vertical datum. The datums are all made to best fit a certain area of the earth for vertical height of for horizontal positioning and sometimes even both. Different datums are constantly being made and mostly of the times made for a special region such as wind park or other big construction sites. Every new datum that's being made and is for universal use can be found in https://www.epsg-registry.org/.

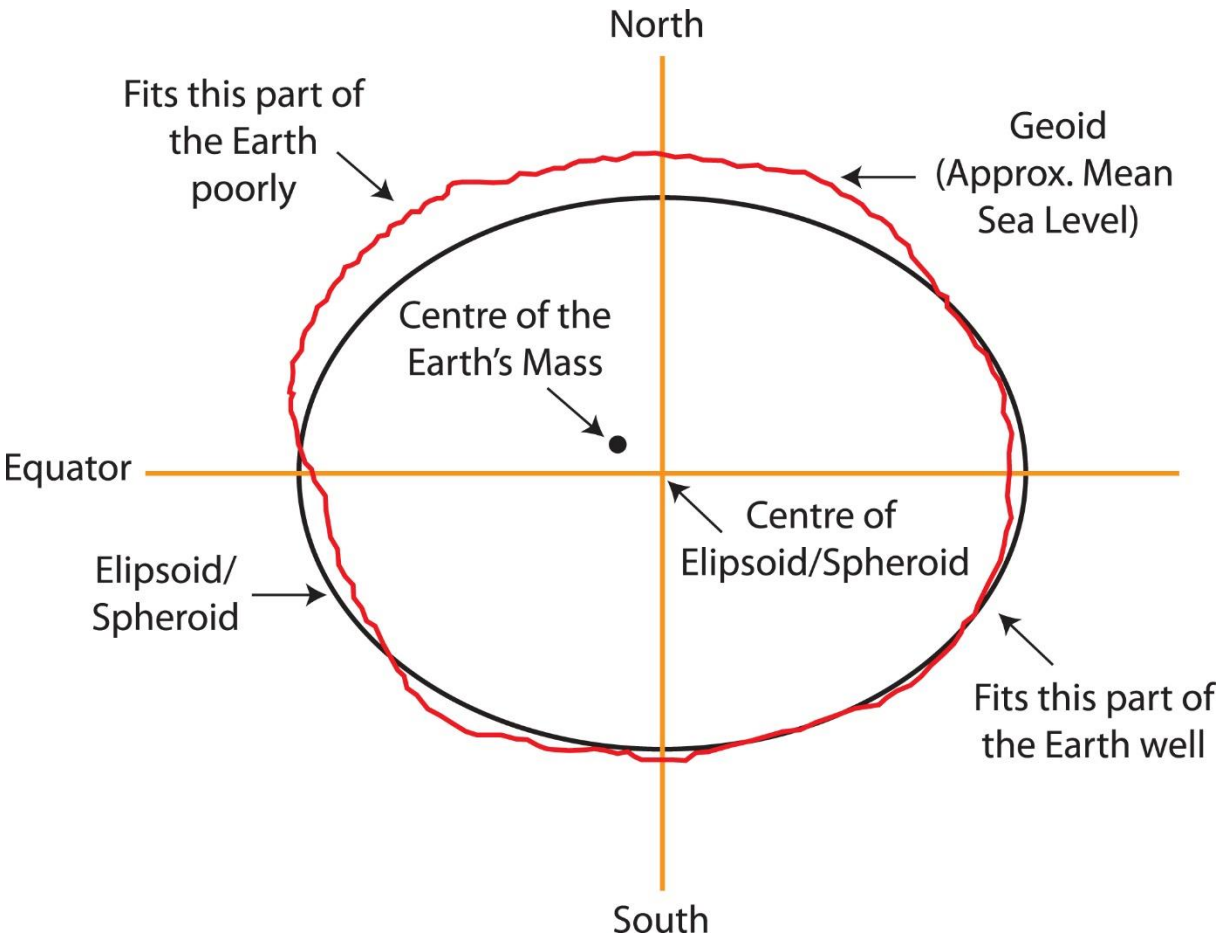

Figure 5http://www.icsm.gov.au/mapping/datums1.html

Horizontal datums

The horizontal datum is the model used to Measure Positions on the earth along the X and Y axil also called latitude and longitude. A specific point on earth can have a significant difference in coordinates, depending on the geodetic datum used. there are hundreds of datums in use at most of them based on a different ellipsoid but there is even datum based on different mathematically shapes. Almost every country has its own default geodetiek datum in use, as an internationally used datum applicable for instance WGS84 or ETRS89 these datums are world covering geodetic datums.

Local datums

Before satellites where in use many countries had their own geodetic datum specially made for their own, and where based on trigonometry and made use of ellipsoids that best fit the areas the where measuring for instance in the Netherlands they use the RD datum based on the Bessel ellipsoid.

Regional datums

After the second world war, basic computers came in use that could help with calculating datum that where fitting for larger areas and not only one country an example of this is the ED50 datum made in 1950.

World datum

At the end of 1950 the American ministry of defence began developing a usable worldwide datum such as WGS 60 what became WGS 66 → WGS72 with the most recent variation called WGS 84.
WGS 84 is a geodetic datum where correction for you positioning are given for from satellites which make it very accurate. This position can have shifted to different positioning datum's such as RD or ED50 and are provided by telecom providers when you use 06-gps.

Parameters

A geodetic datum has different parameters. First, these are the Flatness f and the equatorial radius a of the reference ellipsoid. If the ellipsoid is not geocentric, there are also three translation parameters ΔX, ΔY and ΔZ relative to the centre of mass of the earth. If the ellipsoid is rotated relative to the earth, then there are also three rotation parameters ωX, ωY and ωZ. Finally, there is the scale factor S.

Transformation

To express positions in a certain datum to another datum there is a possibility for small distances, to use pre-determined differences in length and width. However, this is for larger distances to be inaccurate and will need to be made use of transformation formulas to carry out a date conversion. There are different formulas such as the Helmert transformation, the transformation Molodensky and Bursa-Wolf transformation. Not between all datum transformation formulas can be used. During my school period, I learned how to do these transformations and made an excel program for it which I will add to the SOC assignment.

Vertical datum

for measuring a corresponding height or depth to your position it is possible to use the same datum as was used for your horizontal position but the height displayed would be far off to your real height for instance when you are surveying near Bloemendaal and measure your depth in ETRS89 it will give a depth of -45 meter when it is only -3 NAP that why different vertical datum has been developed and are in use.

There are three kind of vertical datums namely:

Orthometric datums: these datums use the earth's gravity field as their datum. And any height measured referencing to that datum can be called a geopotential height.
Tidal datums: tidal datums are as their name suggest are based on the tidal water heights. Tidal datums are local based datum and refer to a certain tidal stage. There are a multiple of tidal stages that are commonly used for this namely: mean low water, mean lower low water and more between every tidal stage is a difference between height sometimes sleight sometimes a lot and all these stages are being differently defined around the world.
three dimensional datums those a made by using a reference ellipsoid and six geocentric parameters expressing their origin and orientation. Unlike a horizontal datum these datums can determine an accurate 3-d position I can give accurate ellipsoid height

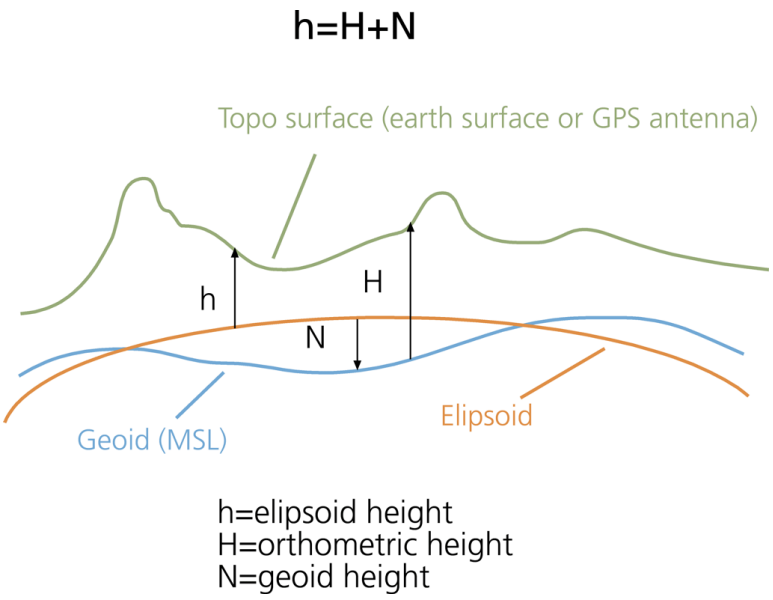

Figure 6 http://www.esri.com/news/arcuser/0703/graphics/geoid2_lg.gif

Vertical datums: orthometric datums

The orthometric height of a point is the distance H along a plumb line from the point to the geoid. The orthometric height is for practical purposes height above sea level but the current NAVD88 datum is tied to a defined elevation at one point rather than to any location exact mean sea level. Orthometric heights are usually used in the US for engineering work although dynamic height may be chosen for large scale hydrographical purposes. Heights for measured points are shown on national geodetiek survey data sheets data that was gathered over many decades by precise spirit levelling over thousands of miles. Since gravity is not constant over large areas the orthometric height of a level is not constant and NGS orthometric height are corrected for that effect for example gravity is 0.1% stronger in the northern united states than in the southern part of the united states so a level surface that has an orthometric height of 1000meter in Montana will be 1001-meter height in Texas. Because the height of the orthometric datum is below the actual surface most values will always be positive

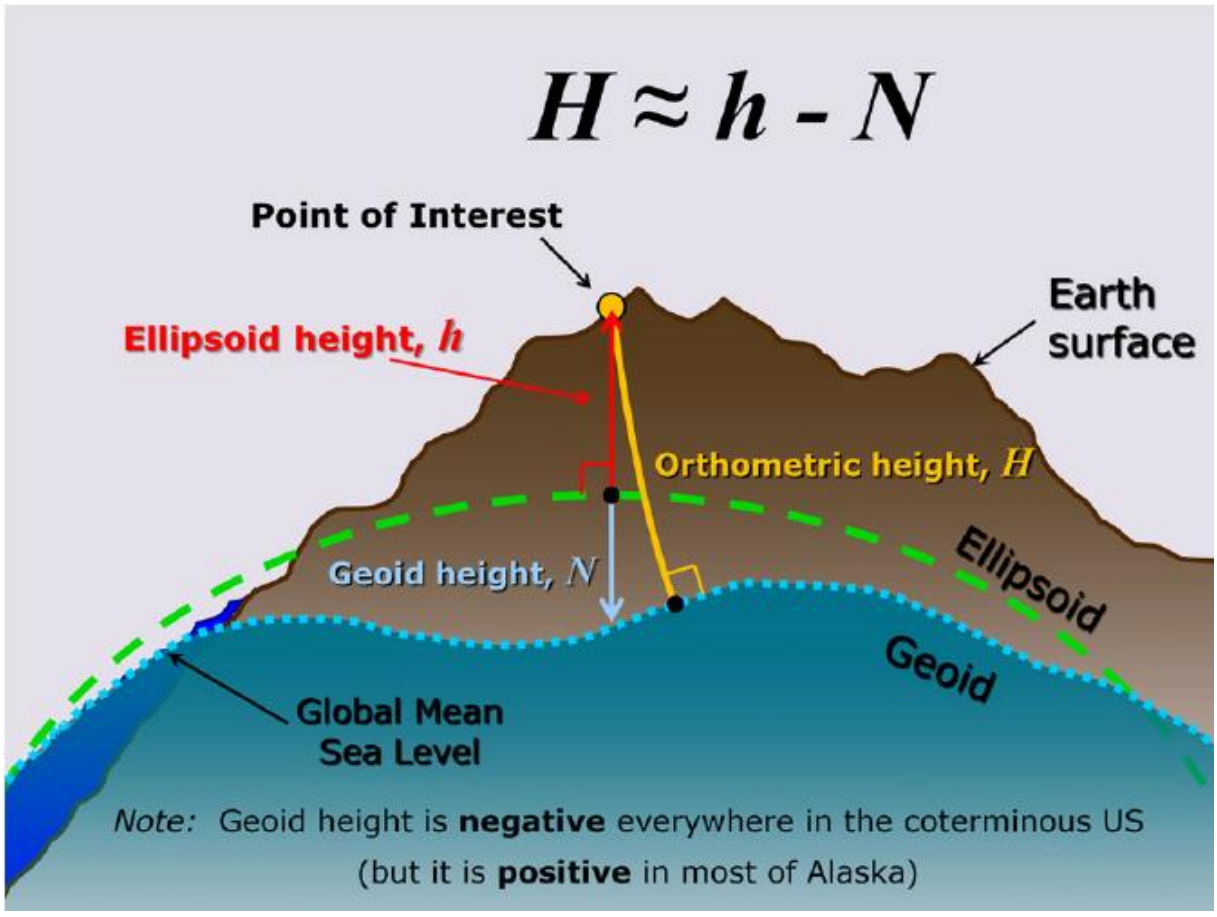

Figure 7https://www.researchgate.net/figure/273133676_fig1_Fig-2-Relationship-between-orthometric-height-ellipsoid-height-and-geoid-height

Vertical datums: tidal datums

In the nautical industry, it is common to use a tidal datum (chart datum) when measuring water depths these are used for surveying as well. Most common is the usage of LAT (lowest astronomical tide) because this reference plane give's an almost guaranteed safety margin of water for the captain but it is not uncommon that the water level drops below LAT due to wind or other contributing factors.
For height reference plane, it more common to use MWHS when you need a minimal clearance for a bridge or to measure the distance to an object such as a light tower or any notable chart features because this reference plane is higher it will generate another safety margin for the captain of the vessel. When there is almost no tidal influence MSL can also be used.

Tabel 1 Veelgebruikte referentievlakken voor diepten / hoogten

Code	Omschrijving
EVRF2000	hoogte in meters tov EVRF2000 (≈ NAP)
OLA	t.o.v. Overeengekomen Lage Afvoer
ASTNMH	t.o.v. astronomisch getij
BODM	t.o.v. de bodem
LLWS1980	t.o.v. Laag Laag Water Spring 1980.0
LLWS1985	t.o.v. Laag Laag Water Spring 1985.0
LLWS1992	t.o.v. Laag Laag Water Spring 1992.0
MAAIVD	t.o.v. maaiveld
HAT	t.o.v. Highest Astronomical Tide
LAT	t.o.v. Lowest Astronomical Tide
MSL	t.o.v. Mean Sea Level
NAP	t.o.v. Normaal Amsterdams Peil
OLR1982	t.o.v. Overeengekomen Lage Rivierstand 1982.0
OLW1972	t.o.v. Overeengekomen Lage Waterstand 1972.0
OLW1982	t.o.v. Overeengekomen Lage Waterstand 1982.0
OLW1991	t.o.v. Overeengekomen Lage Waterstand 1991.0
WATSGL	t.o.v. waterspiegel

Figure 8http://www.geonovum.nl/sites/default/files/Ruimtelijke-referentie_systemen_1.0.pdf

Vertical datum: three dimensional/ reference ellipsoid datum

Thee dimensional datums are based on a reference ellipsoid because this has a constant surface and can therefore be perfectly used for the measuring of x,y position through the use of satellites. Because each reference ellipsoid has a different radius and centre points a specific point can have big differences compared to two different datums. Of this type of datum there are hundreds of local variations but there a few in use that cover large extends of the world one of those is WGS84.

Relatability to my internship

During my internship working with different vertical datums happened on a regular basis because it always depends on the clients wishes. Normally we used RD NAP for our survey's but ETRS89 with LAT also got requested quite often. When we did project on the North sea. And during the Tennet project we had to use a special made geoid model for the vertical height this was based on GRS80 ellipsoid and WGS84 got used for the horizontal plane. The reason I mentioned the DTU10 model was because it was not standard delivered by QINSy and so we had to made it on our own. This of course gave some issue because when we started the project nobody knew anything about measuring in DTU10 and where we could find specification of the DTU10 model. After a lot of phone calls, it became clear that Tennet ordered this model specially for the north-west German coast and it was already implemented on the other ships they were hiring, such as the cable placement ships. When we requested the specifications of the model we only got a picture of some settings in an unknown program. After another few phone calls, we got two. XYZ files from the geodetic firm in Copenhagen. this resulted in the self making of the model for QINSy. This is done by first make a correct database template with WGS84 as horizontal model and vertical with the GRS80 ellipsoid Then load the. XYZ files and export it as a .bin file and copy it in to QINSy database. This was all explained by the QINSy manual and the senior surveyor. But it had to be repeated on every survey pc so I had to do it on the Geosurveyor V.

Sources

https://www.epsg-registry.org/

https://nl.wikipedia.org/wiki/Geografische_co%C3%B6rdinaten

http://www.geonovum.nl/sites/default/files/Ruimtelijke-referentie_systemen_1.0.pdf

https://en.wikipedia.org/wiki/Reference_ellipsoid

https://en.wikipedia.org/wiki/Geographic_coordinate_conversion

https://en.wikipedia.org/wiki/Reference_ellipsoid#Coordinates

https://en.wikipedia.org/wiki/Geodetic_datum

https://elo.nhl.nl/bbcswebdav/pid-413959-dt-content-rid-982099_1/courses/TECH_MI_05_35/Course%20Documents/Hydrografie%20Documenten%20Syllabus%20Hydrografie/Hydrografie%20%28396%20blz%29.pdf

https://vdatum.noaa.gov/docs/datums.html

https://en.wikipedia.org/wiki/Orthometric_height